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The Soviet Aluminum Industry: Slowing Growth and Increasing Dependence on Foreign Raw Materials

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A Research Paper

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The Soviet Aluminum Industry: Slowing Growth and Increasing Dependence on Foreign Raw Materials [redacted] 25X1

A Research Paper

This paper was prepared by [redacted] 25X1
of the Office of Soviet Analysis, with a contribution
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July 1984

The Soviet Aluminum Industry: Slowing Growth and Increasing Dependence on Foreign Raw Materials [redacted] 25X1

Summary
Information available as of 31 March 1984 was used in this report.

The USSR has rapidly expanded its capacity for aluminum production, partly with the help of Western technology. Although most of the capacity installed in the 1960s was of domestic origin, all plants built or under construction since the early 1970s have used Western technology extensively. Imported automated control technology, for example, has helped the Soviets to reduce the industry's high consumption of electric power and to ameliorate its chronic labor shortages. Even though growth has slowed sharply since 1975, the USSR is the world's second-largest producer of aluminum, accounting for 19 percent of world output (the United States is first, accounting for 23 percent). [redacted] 25X1

Because the Soviets treat nonferrous metals as strategic materials, Moscow publishes little data on aluminum production. [redacted] 25X1 25X1 During the 1960s and early 1970s, aluminum production in the USSR increased at an average annual rate of 10 percent, mainly in response to increasing demand from the defense, electrical, and construction industries but also in support of growing export commitments. Since 1975, growth has slowed to an average of 3 percent a year in the 1976-80 period and 1 percent a year in the 1981-83 period. The main causes of the slowdown are:

- A cutback in investment mainly in response to slower growth in demand for aluminum.
- Delays in finishing new production capacity, notably at the Sayansk aluminum plant. 25X1
- Excessive equipment downtime at the Krasnoyarsk aluminum plant, caused by shortages of labor and inadequate maintenance. [redacted]

Because most of the factors causing the production slowdown have continued into the 1980s, we estimate that aluminum production will grow at about 2 percent a year through 1990. [redacted] 25X1

The growth in capacity to produce aluminum has not been matched by expansion in the supporting domestic raw material base. [redacted] 25X1 the share of raw materials obtained from domestic sources has dropped from 70 percent in 1970 to 65 percent in 1982. As a result, the Soviets have had to depend increasingly on imports of bauxite and alumina; this dependence will continue to increase for the balance of the 1980s as domestic reserves of high-grade bauxite are being rapidly depleted. Prospecting throughout the USSR has not revealed any large deposits that would be economical to 25X1

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develop. We project that by 1985 the USSR will import 40 to 45 percent of its bauxite and alumina needs; by 1990 this share will rise to 45 to 50 percent.

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The USSR is also a world leader in aluminum exports, which have been directed mainly to Eastern Europe and Japan. Moscow earns relatively little hard currency from these exports, however, and—as indicated by our projection of relatively slow growth in aluminum production—is unlikely to earn much more through 1990.

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Although Soviet aluminum production is small compared with steel production, wider use of aluminum alloys could help relieve the tension between supply and demand for some types of steel in a limited number of products. Again, however, the relatively small increases in production projected for the 1984-90 period would prohibit a large increase in new applications.

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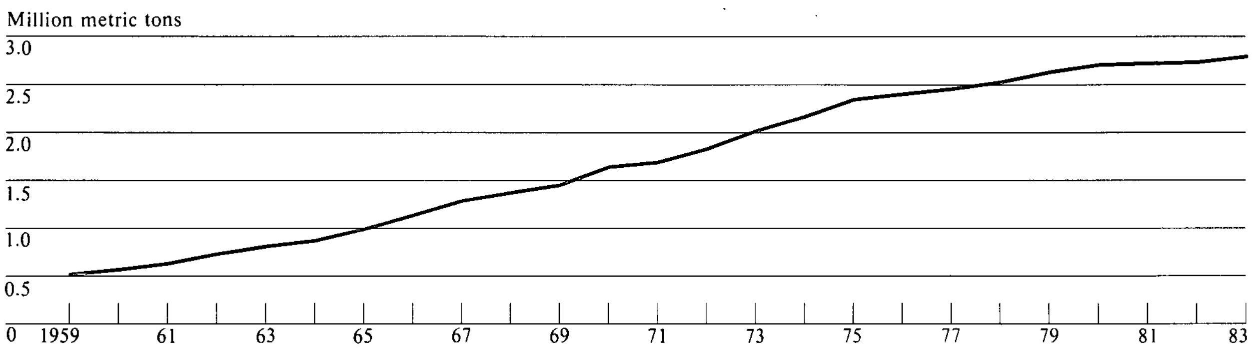

[a] Output of secondary aluminum (recycled aluminum) is not included in this graph; see appendix for a discussion of the methodology used to estimate production.

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The Soviet Aluminum Industry: Slowing Growth and Increasing Dependence on Foreign Raw Materials

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Introduction

Aided by Western technology, the USSR has become the world's second-largest producer of aluminum. It accounted for 19 percent of global output in 1982, while the United States accounted for 23 percent (table 1). A lightweight metal that has relatively high strength, good resistance to corrosion, and good electrical conductivity, aluminum is important to many Soviet industries and is vital to the defense industries. We estimate the latter directly consumes about 15 percent of domestic production of aluminum. This report discusses the Soviet aluminum industry's development over the past 25 years, the contribution of Western equipment and technology, the causes of the marked slowdown in growth since 1975, the growing dependence on foreign sources for raw materials, and the outlook for aluminum production and use in the 1980s.

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Expansion of Capacity, 1959-83

Annual output of aluminum grew from an estimated 515,000 tons in 1959 to 2.8 million tons in 1983 (see figure 1). Nearly 85 percent of this growth occurred before 1976, however, when production grew at an average annual rate of 10 percent a year. In 1976-80, growth slowed markedly to 3 percent a year and during 1981-83 to 1 percent a year.

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Growing export commitments and increasing domestic demand—primarily in the defense, electrical and construction industries—have driven the expansion of the aluminum industry. The industry was created in the 1930s, mainly to support production of military aircraft, and expanded during the next two decades. Since the late 1950s increasing civilian demand and export commitments have also contributed to the industry's growth. Although the share of aluminum production directly consumed by defense has declined (from roughly 35 percent in 1960 to about 15 percent in 1982), the defense industries are still one of the largest and most important single users of aluminum and are granted the highest priority in quality and delivery schedules

Table 1
Leading Producers of Primary Aluminum, 1960-82 [a]

Thousand metric tons

County	1960	1970	1982
United States	1,827	3,607	3,274
USSR	565	1,640	2,735
Canada	691	972	1,075
Japan	133	733	351
West Germany	169	309	723

[a] Primary aluminum is the product of smelting alumina in an electric furnace. US primary aluminum production declined by 30 percent from 1980 to 1982, mostly because of weak markets in the transportation and construction industries caused by declines in the sales of new domestic automobiles and new houses. Japanese aluminum production decreased by almost 70 percent during the same period because high energy costs forced Japan to increasingly rely on less expensive aluminum imports. Source (except for USSR) is the Aluminum Association, Inc., a US-based trade group. Data for USSR derived as explained in the appendix.

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Siberia: The Center of Growth. Most growth in the industry during the 1960s and 1970s resulted from plans made in the 1950s to construct new capacity in southern Siberia where there are relatively inexpensive sources of hydroelectric power (see box, page 3). Over 90 percent of capacity added since then was constructed at four Siberian locations that began production between 1962 and 1967—Novokuznetsk North, Krasnoyarsk, Bratsk, and Irkutsk 25X1 table 2). These plants established southern Siberia as the center of aluminum production and have accounted for about 70 percent of total production annually since 1975 (figure 3). The plants at Bratsk 25X1 and Krasnoyarsk accounted for half of domestic production in 1982. Each has an annual production capacity of roughly 800,000 tons, making them the

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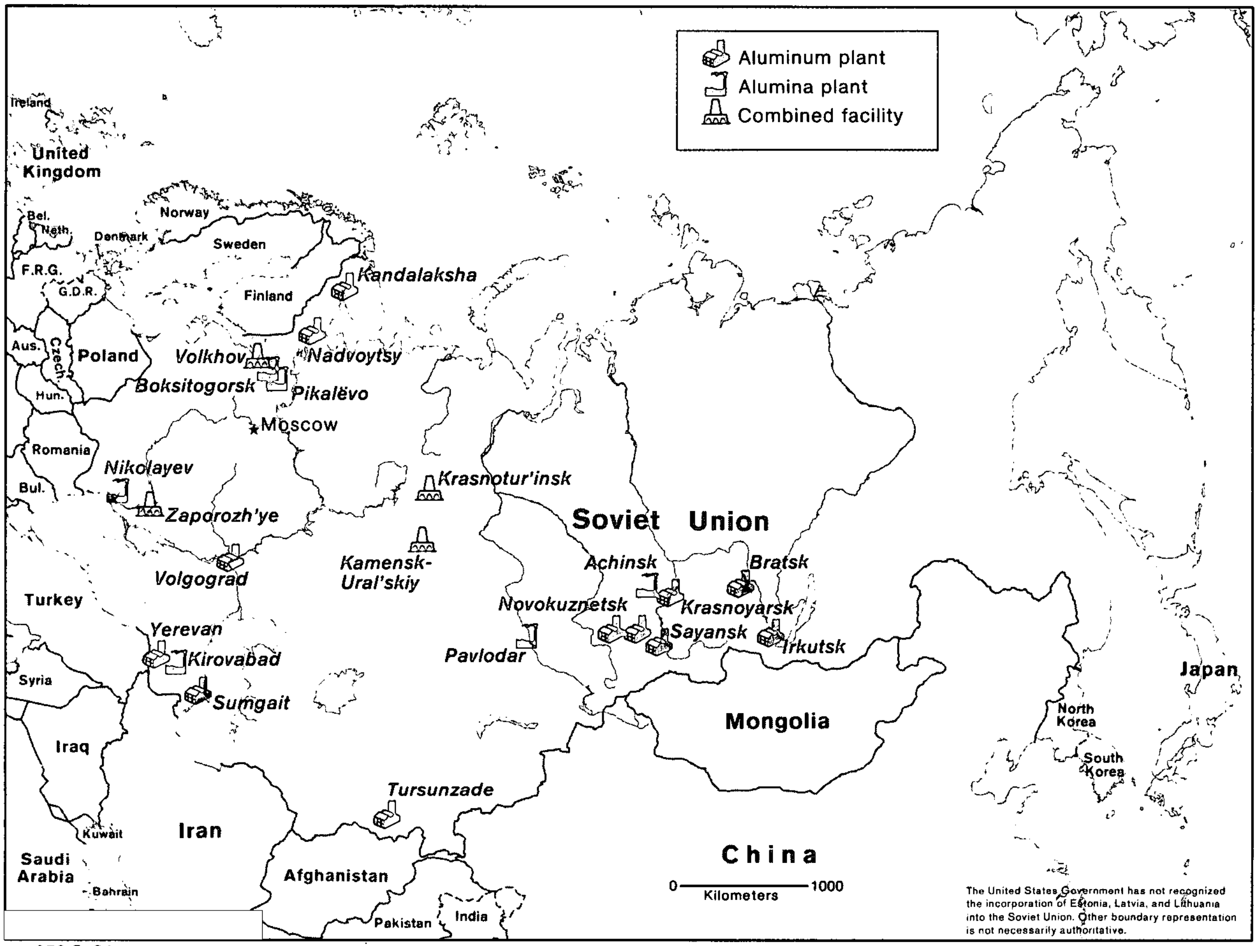
Figure 2
Aluminum Production Facilities



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largest aluminum plants in the world.[1] The only other major addition of new capacity since 1965 has been at Tursunzade in Central Asia. Although this facility began limited production in 1975, it is still under construction and is not expected to reach full output of approximately 400,000 tons until the late 1980s.

[1] The largest US aluminum plant has an annual capacity of about 310,000 tons.

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The Contribution of Western Technology. Growth in aluminum production since 1959 has been fueled by a nearly constant share of industrial investment allocated to the nonferrous metals industry (table 3). Although the trends are not published, the evidence indicates that investment in the aluminum sector has slowed in recent years. A Soviet journal has stated that during the period 1971-75 more than a fourth of the capital investment in nonferrous metals was allocated to the aluminum industry.

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High Power Requirements

The aluminum industry directly consumed more than 4 percent of the electric power generated in the USSR in 1982, making it one of the largest users. Nearly all of this power is used in the electrolysis reduction process, which requires an average of 17,000 to 18,000 kilowatthours (kWh) to produce 1 ton of aluminum.

Aluminum plants are the major industrial consumers of electricity generated by the Siberian hydroelectric power plants (GES). The Bratsk plant consumes 16 billion kWh of electricity a year—nearly 70 percent of the power generated by the Bratsk GES. When completed, the plant at Sayansk will use almost a third of the electric power generated by the Sayansk GES.

Despite the industry's high consumption of electric power and periodic shortages, availability of generating capacity does not appear to have been a major constraint in planning new production capacity. Targets for generating capacity generally have been met in southern Siberia, where most of the growth in aluminum production has occurred.

Much of the investment since 1970 probably reflects expenditures for the acquisition of Western equipment and technology. All new plants built or under construction since the early 1970s—the Tursunzade and Sayansk (figure 5) aluminum plants, the Nikolayev alumina plant (figure 6), and the prebaked anode plant at Tursunzade—use Western technology extensively (see box, page 9, for a discussion of the prebaked anode technology). The Soviets have been trying to upgrade technology used in automation, electric power use, pollution control, and other production-related equipment.

Table 2
USSR: Aluminum Plants

Plant Name	Date of First Production	Estimated Aluminum Production in 1982 [a] *(tons)*
Volkhov alumina and aluminum combine	1932	17,000
Zaporozh'ye alumina and aluminum combine	1933	81,000
Kamensk-Ural'skiy alumina and aluminum combine	1939	87,000
Novokuznetsk aluminum south	1943	72,000
Krasnotur'insk alumina and aluminum combine	1945	71,000
Yerevan aluminum	1950	32,000
Kandalaksha aluminum	1951	53,000
Nadvoytsy aluminum	1954	60,000
Sumgait aluminum	1955	52,000
Volgograd aluminum	1959	172,000
Irkutsk aluminum	1962	238,000
Novokuznetsk aluminum north	1963	163,000
Krasnoyarsk aluminum	1964	672,000
Bratsk aluminum	1966	725,000
Tursunzade aluminum	1975	240,000
Sayansk aluminum	1985 [b]	
Total		**2,735,000**

[a] See the appendix for a discussion of the methodology used to estimate production.
[b] Projected, with probable production of 50,000 tons in 1985. When the plant is completed, production is expected to reach 400,000 tons.

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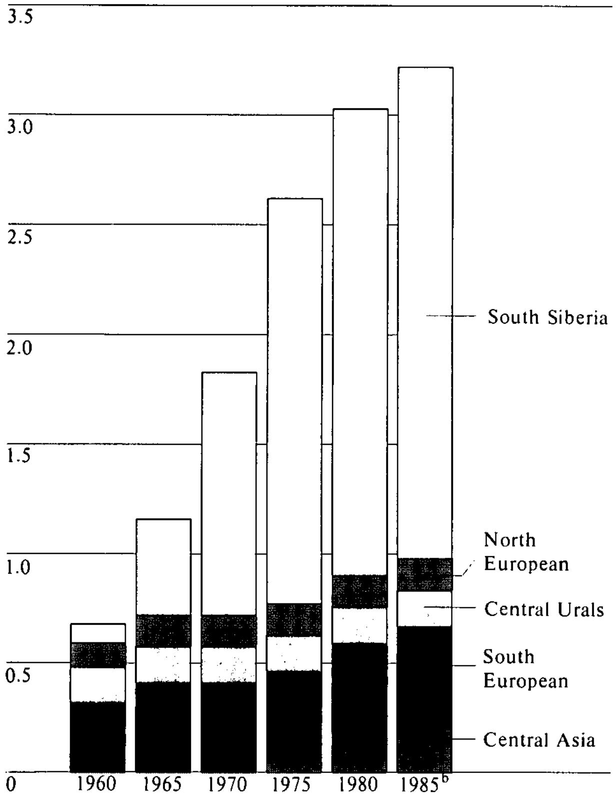
Figure 3
USSR: Growth and Distribution of Capacity for Aluminum Production by Geographic Region, 1960-85[a]
Million metric tons



[a] In this paper the North European region includes the area north of 55 degrees north latitude (roughly north of Moscow) and west of the Urals; the South European region includes the area south of this latitude and west of the Urals.

[b] Projected.

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One of the Soviets' key objectives in seeking Western help in building the Sayansk plant is to gain advanced automation technology so that the plant can operate with less manpower. Negotiations with a US–West German consortium for a smelter that had computerized automated equipment supplied by Alcoa ended in 1979 when the United States embargoed computer technology following the invasion of Afghanistan. In 1980 the Soviets contracted with a West German and French consortium for a smaller smelter (400,000 tons instead of 500,000 tons), technology, and help in building the plant.[2] 25X1

Table 3
USSR:
Five-Year Plans in the Nonferrous Metals Industry

	1966-70	1971-75	1976-80	1981-85 Plan (estimated)
Total *(million rubles)*	6,700	8,700	11,800	14,200
Share of industrial investment *(percent)*	5.5	5.0	5.2	5.1

[a] The Nonferrous Metals Industry investment figure for 1966-70 is from *Ekonomika Tsvetnoy Metallurgii SSSR*, Moscow, 1976, p. 126. The figures for 1971-75 and 1976-80 are from *Tsvetnoy Metally*, September 1983, p. 5. The estimated figure for 1981-85 is based on a Soviet statement that investment in the nonferrous industry during 1981-85 is planned to rise by 20 percent compared with that in 1976-80 (*Ekonomika Tsvetnoy Metallurgii SSSR*, Moscow, 1983, p. 124). Although none of these sources provides an indication of whether the figures are expressed in constant or current prices, the figures for 1971-75, 1976-80, and 1981-85 are probably in constant 1973 prices. However, the 1966-70 figure could be expressed in either 1969 or 1973 prices. In either case, the difference would be small and would not substantially alter the results.

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The Soviets often import technology for new aluminum plants and reproduce the technology in other plants. Potline operations, for example, were partially automated between 1958 and 1978 by installation of computerized equipment (the *alyuminii* system), copied from French equipment and produced in the

[2] The cost of the smelter under negotiation with the US–West German consortium was estimated at $600 million in 1977; that of the West German–French consortium's smelter, about $450 million in 1980. As part of the contract, the West German company (Kloeckner) will buy back 10,000 tons of aluminum a year for two years. 25X1

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Production Processes

Aluminum is extracted from aluminum-bearing ores in a two-step process. Raw ore—such as bauxite, nepheline, or alunite—is processed into aluminum oxide, or alumina. This intermediate product is then sent to an aluminum smelter. Production of aluminum from alumina is based on an electrochemical reaction in which aluminum oxide is decomposed into metallic aluminum and gaseous oxygen in the presence of an electric current. This reaction occurs in specially designed electrolytic cells (also called pots). Alumina is dissolved in these cells in a bath of molten cryolite, a material that acts as a catalyst. The cell is a rectangular steel tank, the inner surface of which is lined with carbon brick and serves as the cathode. The anode, also composed of carbon, is suspended from the top of the cell so that its lower surface is immersed in the molten bath. When a continuous direct current is supplied, molten aluminum accumulates at the bottom of the cell, where it is periodically siphoned off. The molten bath is monitored continuously and replenished when necessary to ensure that there are no interruptions in the reaction.

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The Soviets use two aluminum production processes that differ only in the type of anode used in the electrolytic cell. The type of anode in use at a plant can be identified by analysis of the plant's anode fabrication facility. The Soderberg, or continuous self-baking anode, is formed from a paste consisting of coke, tar, and pitch, which is placed in a rectangular steel mold. The mold is suspended above the electrolytic cell, and as it descends into the molten bath, the bottom portion of the paste is baked. Electricity is supplied to this anode by means of steel pins embedded in the paste. As electrolysis progresses, the baked, lower portion of the anode dissolves and new carbon paste is added continuously to the top of the mold.

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Plants built before 1959 employ the Soderberg process in which current is supplied through a series of steel pins embedded horizontally in the anode paste (HS cells). Beginning with the design of the smelter at Volgograd in 1959, Soderberg anodes with steel pins embedded vertically were employed. This change allowed the Soviets to mechanize aluminum smelting operations. Vertical Soderberg (VS) cells operate well at amperages of up to 160,000 amperes, while the older HS cells are limited to approximately 85,000 amperes. Because the aluminum output of a cell is directly proportional to the cell's operating amperage, the output of a VS cell is theoretically nearly twice that of an HS cell. 25X1

The second process uses a prebaked anode composed of pure carbon that is cast and baked into rectangular blocks. The anode, consisting of a set of such blocks, is suspended above the cell so that its lower portion is immersed in the solution. Blocks are replaced periodically as the reaction progresses. The prebaked process is more energy efficient than the Soderberg method but is otherwise identical. The Soviets began using prebaked anodes (imported from France) in the Tursunzade aluminum plant which began operation in 1975. In 1978, French companies completed construction of a plant at Tursunzade to produce prebaked anodes for aluminum plants. We expect any new Soviet aluminum plants, such as the one under construction near Sayansk, to incorporate this technology. For the same amount of electric current, these prebaked anodes allow higher yields of aluminum per cell than Soderberg anodes. The prebaked anode process also allows a more effective collection and recycling of toxic gases, a serious problem in other aluminum plants. 25X1

Banks of electrolytic cells, or pots, are connected in series and arranged end to end in two rows in long, narrow production buildings called potrooms. Two such potrooms form a complete electrical circuit, or potline, at the majority of Soviet aluminum plants. Plant sizes in the USSR vary from two potrooms to the giant Siberian aluminum smelters that contain up to 24 potrooms. 25X1

Aluminum electrolysis requires high-amperage, continuous direct current. Power entering the plant must therefore be rectified, or converted from alternating current to direct current before it can be sent to the potlines. This is accomplished by a bank of current rectifiers in each potline circuit. These rectifiers are installed in a separate building at one end of each potroom. 25X1

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USSR. This equipment, [redacted] reduced total power consumption in the electrolysis process by 1.5 percent because it more accurately positioned the electrodes in the pots. It also reduced labor requirements on the potlines by roughly 25 percent (although it requires more specialized repair personnel). Assimilation of this system was slow; for example, installation of the first system began at the Volgograd plant in 1959 but was not implemented fully until 1973.[3] [redacted]

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According to a Soviet technical journal, a new automated control system, *elektroliz,* underwent prototype testing at the Volkov plant in 1978 and is slated to replace the *alyuminii* system. This new system reportedly includes Soviet-made M-6000, M-7000, SM-1, and SM-2 minicomputers. The SM-1 and SM-2 minicomputers were copied from imported US Hewlett Packard HP-2116 and HP-3000 minicomputers. [redacted]

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One goal of the 1981-85 plan is to supply technologically advanced anodes—probably from the Tursunzade plant—to existing plants. The Soviets hope that installation of this equipment will reduce the industry's annual consumption of electrical power by 2 billion kilowatthours (kWh) (about 4 percent of total consumption) and significantly increase the proportion of high-quality aluminum produced. [redacted]

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Installation of gas purification systems for pollution control also is scheduled at selected aluminum plants during the 1981-85 period. Controlling pollution has been an important objective since the mid-1970s. The Soviets claim to have spent 100 million rubles on environmental protection equipment for the industry during 1976-80 (most of this was probably at the French-built Tursunzade plant). Decreasing the level of pollution at all of the plants could help ease labor turnover by reducing health hazards.[4] [redacted] 25X1

Why the Slowdown in Production?

The dramatic slowdown in the growth of aluminum production that began in 1976 resulted from:

- A cutback in investment mainly in response to slower growth in domestic demand for aluminum.
- A shortfall in meeting production targets because of delays in constructing aluminum plants.
- Labor shortages and inadequate equipment maintenance.

Slow assimilation of new production technology and periodic electric power shortages exacerbated the slowdown. Delays in rail shipments of raw and semi-processed materials have not substantially affected production schedules because most aluminum plants have stockpiles. [redacted]

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Cutback in Investment. We believe that the primary reason for the much lower growth during the last half of the 1970s was a reduction in investment funding. While no official investment figures for the aluminum industry were published, [redacted] suggested that a large cutback in investment allocation compared to the period 1971-75 severely limited plans for new alumina and aluminum production facilities. Although investment growth in the nonferrous metals industry has grown moderately since 1975, investment in the aluminum industry declined 25X1

[3] As an incentive to stimulate modernization, bonuses are awarded for introducing advanced technology; production targets often are lowered temporarily to allow for assimilation of new technology. Despite these incentives, new technology has been assimilated slowly in plants reflecting difficulties in adapting new equipment into existing production lines and the plant managers' reluctance to make changes because they fear underfulfillment of even reduced quotas. [redacted]

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[4] Excessive pollution inside aluminum plants has been a major problem. Unvented fluoride gas given off in excess during the electrolysis process reportedly causes severe bone deterioration in many potroom workers after several years. Older workers are regularly tested for fluoride levels in urine; if the level is too high, the worker is retired. Younger workers frequently are unwilling to accept this risk to health and find jobs elsewhere. Because of exposure to fluoride, potroom workers work only six hours a day and are allowed to retire at age 45. The short workday means that more potroom workers are needed, thus exacerbating the labor shortage. [redacted]

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partly because of increasing costs and rising investment in other nonferrous metals.[5] [redacted]

Increasing costs and technical difficulties in extracting and processing raw materials have exacerbated the investment cutback in the aluminum industry. A Soviet technical journal has reported that, between 1976 and 1980, the capital investment required to increase production by 1 ton rose 8 percent for alumina and 3 percent for aluminum.[6] [redacted]

The cutback in investment may have been planned partly in response to slower growth in demand. The sharp slowdown in planned industrial output and investment in the 1976-80 period may have caused slackening demand for aluminum as an intermediate product in the machinery sector. Also, military demand for aluminum—which has the highest priority—probably has slowed. We estimate that during the 1976-80 period actual production of aluminum grew much faster than military hardware consumption, largely because of a slowdown in the growth of aircraft and missile production (about 30 percent of the military's aluminum consumption). This trend appears to have continued in the 1981-82 period. [redacted]

Delays in Finishing Planned Construction. Failure to finish construction of new aluminum production capacity is another reason for the production growth slowdown in the period 1976-80. Delays, as well as lower targets for new construction, caused incremental growth of new capacity to fall for the first time since 1959. Only 410,000 tons of new production capacity were added in 1976-80, compared with 790,000 tons added in during 1971-75—a decline of 48 percent (figure 7). [redacted]

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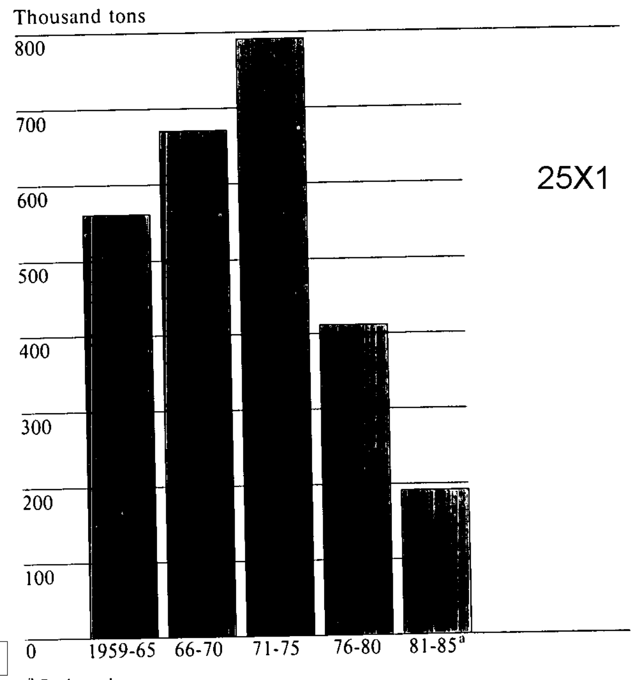
Figure 7
USSR: Additions of New Capacity for Aluminum Production, 1959-85



[a] Projected.

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[5] Soviet literature indicates that the Norilsk Metallurgical Complex probably absorbed most of the increase in investment in the nonferrous metals industry from 1971-75 to 1976-80. Most of this investment probably went to build new copper, nickel, and cobalt production facilities that will supply most of the production increases for these metals during 1981-85. Further, Soviet literature has revealed that, from 1975 to 1980, the aluminum industry's share of total productive fixed capital stock of the nonferrous metals industry declined sharply. [redacted]

[6] As the growth of primary aluminum production has fallen off, the Soviets have begun to increase production from secondary sources—waste and scrap. They claim that using these sources more than doubles labor productivity and requires only 3 percent of the fuel and 16 percent of the capital necessary for production from the raw material. In 1981, production from secondary sources was about 200,000 tons or 7 percent of primary production. (In 1982, US production from secondary sources was nearly 45 percent of primary production.) [redacted]

Nearly all of the scheduled increase in production during 1976-80 was to have come from the startup of new capacity at Sayansk, Tursunzade, Krasnoyarsk, and Bratsk. While production increased at Bratsk and Krasnoyarsk, there have been serious delays at Sayansk and Tursunzade. Delays in building the Sayansk aluminum plant were partly due to the US embargo on the sale of advanced technology, which halted negotiations between Alcoa and the USSR. This project is now scheduled for completion in the 1981-85 Plan. According to Soviet press articles, delays in constructing new capacity at the Tursunzade aluminum plant were caused by poor planning and shortages of construction materials.[7] [redacted]

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The continued sluggish growth of aluminum production in 1981-83 also was due mainly to the inability to complete construction of new facilities.[8] [redacted]

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Labor Shortages and Inadequate Maintenance of Equipment. Labor shortages and inadequate maintenance of equipment contributed to the slowdown in aluminum production growth during 1976-80. Although plant production (in tons) is not available, a 1980 article in a Soviet technical journal cited the giant Krasnoyarsk plant as operating at only 75 percent of capacity.[9] Because this plant accounted for more than 25 percent of capacity during 1976-80, underuse could have a major impact on the total production of aluminum. [redacted]

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Krasnoyarsk's inadequate maintenance facilities and shortage of skilled labor caused excessive downtime of the electrolysis cells, resulting in consistent underfulfillment of production targets. [redacted]

Persistent labor shortages, [redacted] have been a major problem throughout the industry. Generally, the work force is 10 to 15 percent short of prescribed manning levels because of competition for labor from higher paying industries, the health risks associated with excessive pollution, and the location of a large amount of production capacity in Siberia where the harsh living conditions inhibit an influx of labor.[10] [redacted]

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Other Causes. Supplies of electricity have been taut throughout most of the Soviet Union since 1975. Limited supplies, in turn, have resulted in periodic power shortages that have caused cutbacks in production at aluminum plants in the western USSR, including those at Nadvoitsy and Kandalaksha. In Siberia heavy reliance on hydroelectric power has made aluminum plants susceptible to seasonal power shortages due to lack of rainfall.[11] Insufficient rainfall, together with coal shortages at thermal power plants, has led to temporary cutbacks in electric power generation and reductions in aluminum production. One plant has had to take the extraordinary step of periodically shutting down several electrolysis pots because of interruptions in power. Shutdowns entail high restart costs as well as reduced aluminum production. [redacted]

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Increasing Dependence on Foreign Raw Materials

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Since the mid-1960s, domestic output of raw materials and alumina has failed to keep pace with the growth in aluminum production capacity. The Soviets have been unable to meet increasing requirements for domestic raw materials because of the rapidly depleting reserves of high-quality bauxite and the unexpected cost and technical difficulty of exploiting nonbauxite ores.[12] In 1982, domestic high-grade bauxite met roughly 23 percent of requirements for making aluminum (figure 8). [redacted]

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[7] *Izvestiya*, 30 October 1983, p. 2. [redacted]

[8] Construction of new facilities may have a low priority because of an unexpected slowdown in annual increases in demand for aluminum resulting from the slowdown in industrial growth since 1976. [redacted]

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[9] "Attaining Planned Capacities at Nonferrous Metal Enterprises," *Tsvetnyye metally*, No. 7 (July 1980), pp. 31-33. [redacted]

[10] Soviet aluminum plants, particularly the giant Siberian plants, require a large labor force. For example, in 1978 at the Bratsk plant there were 10,000 to 12,000 workers—including wage workers (75 percent), administrative personnel (20 percent), and support service personnel such as electricians, repairmen, and janitors (5 percent). As an incentive, the Bratsk plant pays workers 1.4 times standard wages plus 10 percent extra for each year of employment at the plant for the first five years. Labor requirements are much higher at Soviet plants than they are at US plants because of their lower level of automation and absence of incentives for enterprise managers to reduce cost by saving on labor. [redacted]

[11] Water shortages that began in 1981 caused hydroelectric power shortages through 1983. [redacted]

[12] The USSR is like most industrialized countries in that it does not have sufficient reserves of high-quality bauxite to support its growing aluminum industry. [redacted]

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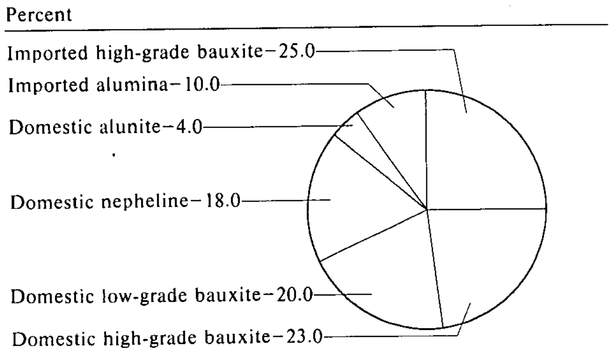
Figure 8
USSR: Sources of Raw Materials for Making Aluminum, 1982[a]



[a] Percentage shares are expressed in terms of aluminum content.

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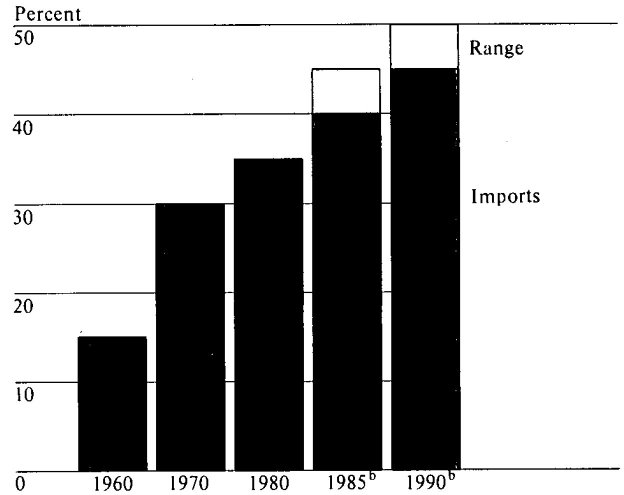
Figure 9
USSR: Imports as a Share of Total Raw Materials Used in Producing Aluminum, 1960-90[a]



[a] Includes bauxite and alumina, expressed in terms of aluminum content.
[b] Projected.

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The only large source of bauxite is the Severouralsk mine in the northern Urals. During 1976-80 it supplied nearly all the domestic high-grade bauxite. Its reserves appear to be nearing exhaustion, however, after almost 50 years of continuous exploitation, and its operation has become more difficult and costly. During 1982, its bauxite production dropped dramatically. A sustained reduction in the amount of bauxite mined will force the Soviets to rapidly increase imports of bauxite.

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Soviet journals have revealed that, despite years of intense prospecting throughout the USSR, no large deposits of high-grade bauxite that are economic to develop have been discovered (see box, page 14). The Soviets have found several small deposits, but their complex geological structure makes them unsuitable for industrial use. Consequently, Moscow has relied increasingly on foreign sources of bauxite and alumina (figure 9).[13]

In 1960 domestic raw materials were used for about 85 percent of aluminum production; in 1970 this share had fallen to about 70 percent, and in 1980 to about 65 percent. Furthermore, the share of aluminum produced from domestic raw materials will continue to decline as aluminum production capacity continues to increase.

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As its dependence on imports has increased, the USSR has stockpiled imported bauxite at three alumina plants located in the European USSR—Nikolayev, Zaporozhye, and Kirovabad. The largest of these,

[13] The USSR has had a long-term bauxite supply agreement with Guinea—its largest supplier—since the early 1970s. Under this arrangement, the Soviets receive about 2 million tons of bauxite a year. The Soviets pay for part of the bauxite through compensating trade; the remainder is shipped as repayment for Soviet investment in Guinean bauxite production facilities. In 1983 the USSR signed a bauxite supply agreement with Jamaica whereby the Soviets will receive 1 million tons of bauxite a year for three years, starting in 1984. Part of the bauxite will be paid for in hard currency and part by compensating trade. Hungary is the USSR's largest supplier of alumina. Imports of alumina are included in a Soviet-Hungarian trade agreement designed to take advantage of relatively cheap Soviet electric power. Under this agreement, first signed in 1961 and recently extended to 1990, 1 ton of aluminum is exported to Hungary for every 2 tons of alumina imported from Hungary. In March 1984, the USSR and Greece signed an agreement that the Soviets would supply technology and equipment to build a 700,000-ton alumina plant in Greece. The Soviets will recoup most of their investment by purchasing 380,000 tons of alumina per year for 10 years at favorable prices.

25X1

High-Grade Bauxite—Search for Substitutes

Recognizing the inadequacy of high-quality bauxite deposits and the desire for self-sufficiency in raw materials, the Soviets planned for extensive use of low-quality aluminous ores—low-grade bauxite, nepheline, and alunite. The USSR has successfully exploited its low-grade bauxite (generally less than 40 percent alumina). Most of these low-quality ores contain large amounts of silica, which increases the cost of processing. Further, many deposits can only be exploited at greatly increased cost because of their remote locations. Despite these costs, the Soviets have continued to increase production of aluminum from low-grade bauxite. In 1982, alumina produced from low-grade bauxite supplied approximately 20 percent of the aluminum industry's requirements.

25X1

Around 1950, the Soviets successfully produced alumina from nepheline at two small plants at Pikalevo and Volkhov in the western USSR. Soviet planners determined that, by using the byproducts of the nepheline process to produce cement, soda, and potash, large-scale production of alumina from nepheline would be 20 to 30 percent cheaper than using domestic bauxite. Plans made in the 1950s called for 50 percent of alumina production in the 1970s to be processed from nepheline. In 1956, construction of a large alumina plant at Achinsk in southern Siberia was planned to exploit local nepheline syenite ores (25-percent alumina content). Construction actually began in 1964 but was not completed until 1972. Delays were attributed to the region's severe climatic conditions and to technical problems in developing large-scale processing of nepheline ores. Many of these problems were not fully solved. By the early 1970s, Soviet planners had concluded that processing nepheline on a large scale was more technically difficult and costly than they had originally thought, so they curtailed extensive plans for this process's development and increased bauxite imports instead. In 1982, alumina produced from nepheline supplied about 18 percent of the aluminum industry's requirements.

25X1

The Soviets' experience in producing alumina from alunite, an abundant nonbauxite ore with only 18 percent alumina content, also did not fulfill their earlier expectations. They had calculated that the cost of producing alumina from alunite would be 40 percent lower than if imported bauxite were used. In 1964, six years behind schedule, the Soviets began production of alumina at Kirovabad from alunite mined at the nearly Zaglik deposits. Severe maintenance problems and shortages of processsing chemicals, resulting in the plant's inefficient, uneconomic operation, have prevented output from reaching the planned 250,000 tons a year. In 1982, production of alumina from alunite supplied about 4 percent of the total requirement for alumina.

25X1

Despite the costs associated with low-grade bauxite, nepheline, and alunite, the Soviets have continued to increase production from these ores. The USSR is the only country to make extensive use of these low-quality ores. Other countries, including the United States, have decided that they are too costly to process on a large scale.

25X1

Nikolayev, is designed to handle foreign bauxite, which is brought in by ship, unloaded, and stored in a large open area

Uses of Aluminum

Aluminum's characteristics make it an ideal material to use in transportation systems, consumer goods, and electrotechnical products. A substitute for some types of steel, aluminum alloys will probably be used more to make up for persistent shortages of steel.[14]

25X1

[14] We are unable to determine the relative costs of production of aluminum or steel. Soviet literature, however, has indicated that substitution of aluminum for steel is often advantageous when weight reduction and corrosion resistance are important. Relying on imports of raw materials rather than on domestic production from costly low-quality domestic ores may keep costs down and help make aluminum attractive as a substitute for steel.

25X1

25X1

Raw Materials Logistics

Aluminum-bearing ores are processed at 10 alumina plants *in the USSR and shipped by rail to the 15 aluminum plants. Each alumina plant can process only one grade or blend of ores at a time because each requires different processing temperatures and times. Thus, each plant usually is limited to a specific source for its supply. Plants generally are near ore deposits to minimize the cost of transporting large quantities of ore. For instance, bauxite from the Severouralsk mine in the northern Urals is processed at the nearby Krasnoturinsk and Kamensk-Ural'skiy alumina plants.* [redacted]

25X1

The primary criterion for locating aluminum plants *has been the availability of inexpensive hydroelectric power because of the enormous amount required for production. Plants can process alumina, a homogeneous material, from any source. Most aluminum plants, however, are not near alumina plants, so large quantities of alumina must be transported long distances. About 70 percent (1 million tons a year) of the alumina produced in the Urals at Krasnoturinsk and Kamensk-Ural'skiy is shipped 2,400 to 3,000 kilometers by rail to Siberian aluminum plants for processing. Some alumina produced at Nikolayev supplies Siberian plants and must be transported over 4,500 km by rail.* [redacted]

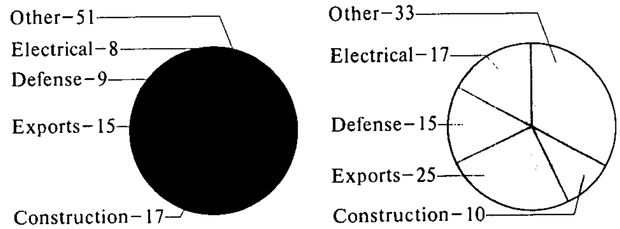
25X1

The Siberian plants require huge amounts of alumina. The annual requirement at Bratsk, for example, is about 1.6 million tons; daily, two or three trains, each with 50 to 60 hopper carloads of alumina, supply this plant. To compensate for occasional delays in shipping, aluminum plants maintain about a 15-day supply of alumina. Despite the quantities of alumina shipped over long distances, shipping charges add only about 5 percent to the cost of producing aluminum; in contrast, electric power constitutes about 40 percent of the total cost. [redacted]

25X1

Defense. Soviet use of aluminum in production of defense durables and other military-related activities currently takes about 15 percent of domestic production (the US defense sector takes about 9 percent of domestic production) (figure 10). Aluminum is used in manufacturing most major weapon systems including aircraft, missiles, ships, and land armaments. *Aircraft production* consumes about 25 percent of the aluminum delivered to military industry. Several different aluminum alloys are used to make structural airframe components to meet weight, strength, and other design requirements. For example, a Defense Intelligence Agency assessment of the applications and properties of alloys used in the structural airframe of a MIG-21 (Fishbed), a general purpose fighter aircraft produced for the Soviet Air Forces from 1959 to 1979 and now produced for export, indicates that aluminum accounts for more than 50 percent (3 to 4 tons) of the empty weight of the aircraft. *Missile production* consumes about 6 percent of aluminum delivered to the military. Nearly all airframe bodies of surface-to-air missiles are made from aluminum alloys. [redacted] 25X1

Figure 10
United States and USSR: End Uses of Aluminum, 1980



[redacted] 25X1

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Civilian. In the USSR the electrical industry consumes some 17 percent of aluminum production (it takes about 8 percent in the United States).[15] In the

[15] These estimates include only civilian consumption. Defense consumption of aluminum for construction and electrical use is included under defense. [redacted] 25X1

Table 4
USSR: Unwrought Aluminum Exports, 1970-82 [a]

Thousand metric tons

	1970	1971	1972	1973	1974	1975	1976	1977	1978 [b]	1979	1980	1981	1982
Total	369	406	455	518	529	502	538	572	621	570	566	566	600
Of which:													
Eastern Europe	282	316	357	388	394	379	403	403	426	429	452	428	410
Japan	25	21	38	47	42	43	69	92	111	74	62	65	82
France	1	14	14	12	9	12	14	24	30	21	11	5	40
Other OECD	34	27	40	41	49	45	41	38	38	27	23	25	28

[a] This table includes only unwrought aluminum. Data for wrought aluminum (mostly rolled products) are not available after 1975; Soviet wrought aluminum exports amounted to 101,500 tons in 1975, most of which probably went to CEMA countries. Data for 1970 to 1975 for total aluminum exports are taken from official Soviet trade statistics; data after 1975 were taken from UN trading partner statistics and may be slightly understated because some countries do not report data to the United Nations; East European trade data from 1970 to 1975 were taken from official Soviet trade statistics; data after 1975 were taken from East European trade books, where available (Poland, East Germany, Bulgaria, and Romania imports for 1975 to 1982 were estimated); Soviet imports of aluminum are negligible.

[b] From 1978 to 1980, exports of unwrought aluminum declined, from about 621,000 tons in 1978 to about 566,000 tons in 1980. Nearly all of the fall in exports during this period was to OECD countries (particularly Japan and France) probably because of changing world market conditions. Similarly, an upturn in world demand interrupted and reversed the slide in 1981-82.

25X1 [redacted]

1960s the Soviets began substituting aluminum for copper in power cables and wire. By 1970 about two-thirds of electric power cables were made with aluminum; the Soviets plan to eventually produce all power cables from aluminum. Aluminum plants at Bratsk and Irkutsk account for 70 to 80 percent of production of aluminum wire rods. The Sayansk plant will have a large facility for making wire rods that will increase total production substantially. [redacted] 25X1

Roughly 10 percent of aluminum production in the USSR goes to the construction industry (about 17 percent in the United States). Aluminum is used to make various building products, including window frames, doorframes, and building panels. Aluminum building panels, lightweight and easy to handle, are used extensively in Siberia where tne harsh climate makes handling materials difficult. [redacted] 25X1

Although obtaining allocations of aluminum for new products is often difficult and periodic shortages occur in industries that have low priority (transportation and consumer industries), production of aluminum appears to be sufficient to meet most of the domestic demand. Moreover, the USSR has consistently exported at least 20 percent of its domestic production.[16] [redacted] 25X1

Trade. The USSR is the world's second leading exporter of unwrought aluminum.[17] It exported roughly 600,000 tons in 1982—nearly a fourth of domestic production. Of this, nearly 70 percent went to Eastern Europe—mainly East Germany, Czechoslovakia, Yugoslavia, and Hungary (table 4). The USSR is not a significant force in the non-Communist aluminum market; in 1982 such exports amounted to only about 165,000 tons, with almost 50 percent going to Japan. [redacted] 25X1

[16] Despite an export surplus, the USSR would not be able to increase the production of aluminum fast enough to meet a sudden, large increase in total demand. There is little slack at most alumina and aluminum plants, and construction of new production capacity requires long leadtimes, even at locations where adequate transportation and electric power are available. A large increase in military demand, however, could probably be met by reallocating aluminum to defense industries from nondefense consumers, reducing aluminum exports, and drawing down national stockpiles of aluminum. [redacted] 25X1

[17] Unwrought aluminum has not been worked by cold-rolling, forging, pressing, drawing, or extension. [redacted] 25X1

Although the USSR imports more than one-third of the raw materials needed to make aluminum and only exports about 25 percent of aluminum production, there is probably a net economic gain in its trade balance because of the large price difference between raw materials and aluminum.[18] Sales of aluminum have been a relatively small but stable source of hard currency earnings for Moscow for several years. In 1983, exports of aluminum probably earned $250-300 million, supplying about 1 percent of total hard currency earnings for the year. [redacted]

25X1

Outlook

The expansion of Soviet aluminum production is scheduled to proceed even more slowly during the 1981-85 period than in the previous five-year period. Production in 1985 is planned to be 15 to 20 percent or 400,000 to 500,000 tons greater than in 1980, reaching an estimated 3.11-3.25 million tons (table 5). Some of this growth may come from modernization of plants and a rising share of capacity use at the Krasnoyarsk aluminum plant, but most will have to come from construction of new production capacity.[19] If new plants operate at the same level as most existing plants (90 percent of capacity), at least another 450,000 to 550,000 tons of new production capacity will have to be brought onstream during the period to meet the 1985 goal. The Soviets have announced plans for new production capacity at Bratsk, Krasnoyarsk, Tursunzade, and Irkutsk; they also intend to begin production at the Sayansk plant by 1985. On the basis of our analysis [redacted] we estimate that the Soviets will increase production capacity by only 190,000 tons, far less than required to meet the planned output targets. As a result, the average annual rate of growth of aluminum production will fall to about 1 percent a year in 1981-85 compared with the 3-percent-a-year average achieved during 1976-80.[20] [redacted] 25X1

Table 5
USSR:
Projected Production of Primary Aluminum, 1984-90 [a]

Year	Production (thousand metric tons)	Increase (percent)
1984	2,845	2
1985	2,895 [b]	2
1986	2,955	2
1987	3,015	2
1988	3,075	2
1989	3,145	2
1990	3,250	3

[a] Output of secondary aluminum (scrap, recycled aluminum) is not included in this table; see the appendix for a discussion of the methodology used to estimate production.
[b] Soviet literature states that aluminum production in 1985 is planned to grow by 15 to 20 percent over the 1980 level, reaching an estimated 3,110,000 to 3,250,000 metric tons.

[redacted] 25X1

We project that Soviet aluminum production will grow at a rate of about 2 percent a year during 1986-90, reaching 3,250,000 tons by 1990. [redacted] 25X1

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25X1

[18] The February 1984 spot-market price for aluminum, for example, was $1,650 per ton while the spot price for bauxite was about $30 per ton (from 4 to 8 tons of bauxite are required to produce 1 ton of aluminum, depending on the grade of bauxite). A precise calculation of the net balance of trade is not possible, however, because some of the imported bauxite and exported aluminum is paid for through compensation agreements rather than hard currency. Also, most Soviet exports of aluminum are to Eastern Europe and are not paid for with hard currency. Finally, other factors also have to be considered such as the net cost of imported equipment used to produce aluminum. [redacted]

[19] According to Soviet literature [redacted] many aluminum plants are scheduled for equipment modernization during the 1980s. All evidence indicates that, to date, none of the capacity shown in table 2 has been retired. [redacted]

[20] The Soviets have not disclosed specific targets for aluminum produced from scrap; however, they plan to increase the production of all nonferrous metals from secondary sources by 20 to 25 percent during 1981-85. Production of aluminum from secondary sources probably will increase at a slower rate than these figures suggest because, as Soviet publications note, aluminum scrap collection is disorganized and most aluminum is not recycled. Further, secondary processing facilities, which do not have proper equipment, produce low-quality aluminum of limited use. [redacted] 25X1
[redacted] two to four years is required for construction of new capacity at existing aluminum plants, and up to 10 years—from the start of construction to initial production—are required for new plants. For example, in 1965 the Soviets announced plans to build the Tursunzade plant in Tadzhikistan. Although construction started in 1966, production did not begin until 1975. [redacted]

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25X1

Despite the slow rate of growth that we project, there probably will not be domestic shortages of aluminum. A large increase in domestic consumption, however, probably would force a substantial reduction in exports. For example, if total domestic consumption were to grow at the same average annual rate as planned total industrial output in 1981-85—4.7 percent—the Soviets could meet this demand by reducing aluminum exports about 10 percent each year from the previous year. Because of long-term trade agreements with Eastern Europe, such a decrease would probably eliminate aluminum exports to the West by 1990, while forcing a small reduction in those to Eastern Europe. As a second example, if military consumption alone increased as much as 10 percent a year from 1984 to 1990, even allowing for a 2-percent annual increase in civilian consumption, aluminum exports would have to decline at a rate of about 1 to 2 percent a year.[22] [redacted]

25X1

There is considerable potential for growth of aluminum use for civilian purposes, particularly in transportation, container and packaging, and consumer durables.[23] Soviet industries generally use a higher percentage of steel products than Western countries do. Although Soviet aluminum production is small compared with steel production, wider use of aluminum could help offset shortages of some types of steel for a limited number of products. For example, increased use of aluminum cans would cut losses from food spoilage.[24] The small increases in aluminum production projected for 1984-90, however, will not be sufficient to encourage new applications. [redacted]

25X1

[22] These scenarios assume no change in stocks. [redacted]

[23] Accurate Soviet aluminum consumption statistics are not available for these industries. However, use of aluminum in these industries is at an early stage compared to that in industrialized Western countries. In the United States, the transportation, containers and packaging, and consumer durables industries accounted for about 3,000,000 tons of end-use shipments of aluminum products in 1982, more than total Soviet aluminum production in that year. For example, production of beverage cans in the United States required the largest share of aluminum sheet and reached 53 billion cans in 1982. [redacted]

[24] Aluminum container production is different from steel container production. To produce more aluminum containers, the Soviets would have to import or produce the necessary equipment. Losses from food spoilage are a major problem in the USSR and have amounted to 20 to 30 percent of total farm food production in the 1980s. [redacted]

Shortages of labor will continue to be a major problem in the aluminum industry. Although planners have emphasized that increased automation would reduce the need for large numbers of laborers, the USSR has been unable either to produce the necessary equipment or to rapidly assimilate and spread foreign technology. Moreover, introduction of automated equipment may not be the hoped-for panacea because there are few trained technical personnel at aluminum and alumina plants. If the introduction of more advanced equipment were accelerated, requirements for specialized technicians would probably increase faster than their supply. [redacted] 25X1

Taut supplies of power probably will continue to limit expansion of the aluminum industry and interrupt production at plants in the western USSR. Seasonal droughts in Siberia, even though they probably will continue to cause periodic shortages of electric power, will not constrain future expansion of the aluminum industry there. [redacted] 25X1

Meanwhile, depletion of reserves of high-grade bauxite will continue and will cause mining to become increasingly expensive. The Soviets, therefore, will be forced to import increasing amounts of bauxite and alumina. [redacted] 25X1

In 1982 the Soviets imported about 10 percent of their alumina needs. Unless there is a major expansion in alumina production capacity, they will be forced to increase imports to meet increased aluminum production plans. [redacted] We project that Soviet dependence on foreign markets for raw materials will increase from 35 percent in 1980, to 40 to 45 percent in 1985, and to 45 to 50 percent in 1990. [redacted]

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Appendix

Estimating Soviet Production

Our estimate of Soviet aluminum production is derived by adding the estimated production of each of the 15 aluminum plants in the USSR. We estimate production by assuming that new capacity operates at 50 percent of estimated maximum capacity during the first year of operation and 90 percent afterward.[25] The one exception is at the Krasnoyarsk plant. As noted earlier, in 1980 this plant was reported as operating at reduced capacity. Using this method, the production time series in table 6 was derived by adding the production from annual additions of new capacity based on correlating Soviet announcements of new additions to capacity with overhead photography. [redacted]

25X1

The calculation of maximum production capacity at each plant is based on information derived from [redacted] technical specifications of aluminum plants. [redacted]

25X1

25X1

25X1

[redacted]

25X1

An alternative method provides another helpful cross-check of our methodology. According to Soviet literature, in 1937 the USSR produced 37,700 tons of aluminum.[26] This is the only figure on aluminum production ever known to be published in the USSR.

Table 6
USSR:
Estimated Production of Primary Aluminum, 1959-83 [a]

Year	Production *(thousand metric tons)*	Increase *(percent)*
1959	515	
1960	565	10
1961	630	12
1962	730	16
1963	810	11
1964	870	7
1965	990	14
1966	1,135	15
1967	1,285	13
1968	1,370	7
1969	1,450	6
1970	1,640	13
1971	1,690	3
1972	1,830	8
1973	2,015	10
1974	2,165	7
1975	2,345	8
1976	2,400	2
1977	2,455	2
1978	2,525	3
1979	2,630	4
1980	2,705	3
1981	2,720	1
1982	2,735	1
1983	2,795	2

[a] Output of secondary aluminum (recycled aluminum) is not included in this table.

[redacted]

25X1

[redacted]

25X1

[25] The 50-percent figure is used to account for low production associated with equipment startup. The 90-percent figure was derived by taking the ratio of reported production data and our estimate of production capacity for plants where data are available. [redacted]

25X1

[26] Itogi Vypoleniya Vtorogo Pyatiletnogo Plana Razvitiya Narodnogo Khozyaystvo Soyuza SSR, Moscow, 1939, p. 24. [redacted]

25X1